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Health awareness and the transition towards clean cooking fuels: Evidence from Rajasthan*

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Abstract

Worldwide, about 2.9 billion people cook and heat using open fires and simple stoves burning solid biomass like wood, dung or agricultural residues. The inefficient combustion process causes high emissions of aerosols and gaseous pollutants evoking serious adverse impacts on human health and the environment. To mitigate these health risks and the associated detrimental climate active emissions, multiple initiatives have promoted the use of cleaner cooking technologies and fuels. In this context, the Indian government currently promotes the use of Liquefied Petroleum Gas (LPG). A large-scale program essentially covering the upfront costs of the new technology has increased the number of households with LPG stoves by more than 70 million since 2016. However, even after adopting LPG, a major fraction of the rural population continues to rely on solid biomass as their primary cooking fuel. One reason for the limited use of LPG could be that the health effects of traditional cooking are not sufficiently known to the households. We examine this hypothesis through an experiment providing randomized health information to 550 respondents with low LPG consumption in rural Rajasthan. Our results indicate that health information significantly increases the reported willingness to pay for LPG and has a strong positive impact on consumption behavior. We show that the causal mechanism indeed works via improved health knowledge, which is significantly higher among households receiving the health information. We also find suggestive evidence that knowledge-building regarding the health effects of cooking fuels should not target women alone.

Keywords: Household air pollution, Health, Clean cooking fuels, Energy access, Willingness to pay, Experiment, India

1 Introduction

Across the world, about 2.9 billion people cook and heat using open fires and simple stoves burning solid biomass like wood, dung or agricultural residues. The consequences for human well-being are severe: household air pollution from solid cooking fuels is responsible for approximately 4 million premature deaths annually, caused by chronic lung disease, childhood pneumonia, cardiovascular disease and cancer (WHO, 2014). In India, the health burden from traditional cooking is particularly high. About 52% of fine ambient particulate matter concentration in the country is caused by residential energy use (Conibear et al., 2018) and it is estimated that almost one million people die prematurely from household air pollution every year (Smith and Sagar, 2014, p. 411).

Cleaner fuels such as liquefied petroleum gas (LPG), biogas or electricity, can alleviate much of the health burden and of the emission of climate-active pollutants from the inefficient combustion of solid biomass.

In this context, the Indian government is currently promoting large-scale access to LPG. LPG has been available in India for a long time already at centrally administered and subsidized rates. While LPG has become widespread in urban areas, financial constraints have made it very difficult for many rural households to cover the upfront cost of adopting the technology (Jain et al., 2015). In addition, LPG supply was limited in rural areas (Cheng and Urpelainen, 2014).

The Indian government's "Pradhan Mantri Ujjwala Yojana" (PMUY) program was launched in 2016, with the intention to change this situation by essentially covering the upfront costs for LPG for low-income households.[1] Supported by improved supply and strong campaigning, since 2016, the num-

[1] See http://www.pmujjwalayojana.com/ for more information.

ber of households registered as LPG users has already increased by over 70 million. However, many households who adopted LPG under the program continue to rely on traditional biomass for a major part of their cooking. Based on multi-year LPG sales data from Karnataka, Kar et al. (2019) show that PMUY beneficiaries buy less than half the amount of LPG cylinder refills as compared to general consumers in rural areas.

Low or fluctuating income levels and supply side constraints can no doubt inhibit a switch to regular use of LPG in the Indian context (Heltberg, 2004). However, in addition, households may simply not be aware of the important advantages of LPG beyond the time saving effects and the convenience involved. While LPG is advertised as a clean fuel, our interviews show that women in rural Bikaner are unaware of the severe health risks they incur by cooking with traditional biomass. Given such serious lack of information, even without financial constraints or supply constraints people may not see sufficient reason to switch to LPG as their primary cooking fuel.

Hence, providing appropriate health information could be key to induce the transition to sustained use of clean cooking fuels. Related literature has shown that convincing households of health benefits may not be an easy task (Mobarak et al., 2012; Beltramo et al., 2015). But, to the best of our knowledge, this has never been tested in the concrete context at hand. The closest literature relates to LPG use in Kerala and Uttar Pradesh (Krishnapriya, 2017) and willingness to pay (WTP) for improved biomass stoves in rural Bangladesh (Mobarak et al., 2012), where upfront costs were relatively high and constituted an important barrier (see also Bensch et al., 2015). This paper now examines the effect of brief health information on WTP and LPG consumption in a context where the problem of high upfront cost was already taken care of.

Our evidence is based on a survey of 550 households in rural Bikaner district in Rajasthan. Health information was randomly administered to one part of the respondents, while the others received some general information on LPG. We then measured the treatment effect on two variables: (i) the necessary financial compensation to induce households to double their LPG consumption at given prices (based on self-reported WTP in the context of an adjusted Becker-DeGroot-Marschak procedure (Becker et al., 1964)), and (ii) the actual increase in consumption (measured by the households' use of a voucher for a new refill before a given deadline).

The paper is organized as follows: Section 2 provides an overview of the extant literature regarding the effect of health information on household fuel choice and cooking habits. In section 3 we develop the conceptual framework. Section 4 presents the sampling strategy and the methodological approach including the design of the experiment. Results are presented in Section 5, and Section 6 concludes with policy insights from the study.

Overall, our experimental evidence suggests that health information is highly effective and should be included in the campaigns to promote LPG. We also provide some tentative evidence that it may be useful to target not just women, but also men.

2 Health awareness and fuel choices

While there is an extensive literature on household fuel choice decisions in low- and middle-income countries (for an overview see, e.g., van der Kroon et al., 2013; Lewis and Pattanayak, 2012; Muller and Yan, 2018) there are only a few studies examining the effect of health information on households' decision making in this respect.

2.1 Lacking knowledge about health hazards

The available evidence suggests that the knowledge about the health hazards of traditional cooking is very poor. While a majority of households recognize that there are some health hazards related to indoor aid pollution (Jain et al., 2015; Mobarak et al., 2012), they largely underestimate the severity of these risks (Mobarak et al., 2012). Furthermore, they consider information that demonstrates the severity of these risks as highly salient (Beltramo et al., 2015).

Hence—as also suggested by Jain et al. (2015)—the existing knowledge gap may be an important hindrance for the greater uptake and use of clean cooking fuels in India and elsewhere in the world. To bridge the knowledge gap, the most natural intervention is to provide information. Given that the knowledge gap is so profound, the effect of providing information may be substantial.

2.2 Mixed findings on the role of health information

The few studies that have examined the effect of health information on household cooking fuel or technology use in a systematic way are primarily related to the introduction of improved biomass cookstoves.[2] In a descriptive survey-based study, Jin et al. (2006) suggest that health education alone may not be effective unless it is coupled with access to improved technology in the form

[2]Multiple initiatives have promoted the use of efficiency-enhancing improved cookstoves. These stoves have often not been well accepted by households though, which is also true for India, where the adoption of improved biomass cookstoves has been limited (Khandelwal et al., 2017). In addition, it remains disputed to what extent these stoves have been able to reduce household air pollution sufficiently to generate the required health benefits (for contrasting findings see e.g. Bensch and Peters, 2015; Smith et al., 2011 on the one hand, and Sambandam et al., 2014; Hanna et al., 2016; Mortimer et al., 2017 on the other hand). For these reasons, many experts now expect that promoting the direct switch to electricity or clean fuels such as biogas or LPG will lead to a greater reduction of household air pollution and hence to greater health benefits (Puzzolo et al., 2016).

of culturally well-adjusted stoves. Similarly, using a differences-in-differences design based on data for Tibet, Tun et al. (2005) find no significant effect of health counselling on fuel change, despite the fact that significant changes in the relevant knowledge are observed.[3] In contrast, based on survey data from urban Indian households, Gupta and Köhlin (2006) find that believing that wood does not cause pollution significantly increases the quantity of firewood used.

Evidence from experimental studies is not quite conclusive either. In a randomized control trial with a clearly defined and strong health-information treatment in Uganda, Beltramo et al. (2015) do not find consistent evidence that information on the benefits of fuel-efficient cookstoves with regards to health and time-savings improves WTP. The direct reaction to payment modalities is much stronger than to the health information.

There are also a number of other randomized control trials related to the adoption of improved cookstoves that use health information as a part of an intervention. However, in these studies, information on the health benefits of the improved stoves is provided for all treatment arms, and randomization refers to other factors (Miller and Mobarak, 2015, 2013; Mobarak et al., 2012). These studies can therefore not provide any information on the effect of health messaging itself.

Mobarak et al. (2012) note a low willingness to pay for the improved stoves despite the health information. This observation is in line with the role of liquidity constraints highlighted by Beltramo et al. (2015) or with financial constraints more generally that may prevent households from buying the stoves. Indeed those studies providing clear evidence for successful health-information interventions tend to consider situations in which such large

[3] See Barnes (2014) for a review of these and other related studies.

upfront cost do not exist. They focus on behavioral change such as taking the children out of the kitchen, or cooking outside or with open doors, rather than in a closed room (see e.g. Barnes et al., 2011).

2.3 Insufficient evidence in the LPG context

In the specific context of LPG use, there is almost no evidence on the role of health information. A notable exception is the field experiment by Krishnapriya (2017) that covers the effect of health information with respect to LPG uptake among other household choices of fuels and appliances in rural communities of the Indian states of Kerala and Uttar Padesh. Households were confronted with information of different levels of intensity. It turned out that even the most intensive information through posters in the village, leaflets and one-to-one explanations to representatives of each household did not lead to a significant switch of households towards cleaner fuels, except for the case of Kerala when the information was provided to women. In contrast, with regards to electric appliances (such as the purchase of LED bulbs) the information treatment led to significant results. As purchasing a bulb requires a much smaller investment than purchasing an LPG stove, the most plausible explanation seems to be that LPG uptake is largely determined by liquidity constraints or financial constraints more broadly. Since the convenience of LPG use is more or less undisputed, alternative explanations are less plausible here.

2.4 New situation as upfront costs are covered

If the above reasoning is correct, the introduction of the government's PMUY program in 2016 should have significantly changed the situation by lifting the major constraint for the spread of the LPG technology. By offering

LPG connections for free to poor rural households, the large upfront cost is taken care of. 'LPG connection' thereby refers to the establishment of a formal account with a distributor as well as to the actual connection of the LPG stove to the LPG cylinder with a hose and a regulator. At current prices, this LPG connection comes at a fee of 1600 INR (about 25 USD), and the additional cost for the first cylinder and the LPG stove are about 480 INR and 1020 INR respectively, i.e., another 1500 INR. Total upfront cost hence amount to around 50 USD, which is difficult to bear for poor rural households. In the context of the PMUY the government completely takes over the cost of the LPG connection, and in addition, it provides the opportunity to purchase the first cylinder and the LPG stove on the basis of a loan by the distributors that is gradually repaid by a an increase in the price of subsequent refills by approximately 170 INR.

As mentioned in the introduction, this opportunity to receive an LPG connection, stove and the first cylinder initially free of charge has already driven over 70 million households to adopt the new technology. If financial and credit constraints are no longer binding, the relevant health information should now be able to make a difference on actual use.

Of course, for a poor rural household, even the purchase of a refill for 480 INR (or more if some of the repayment of the loan for the stove and the first cylinder is added to the bill of the refill) is a large investment. Hence, in our context, financial constraints that prevented the initial uptake before the PMUY may also prevent households from purchasing refills of the LPG cylinder. The fact that domestic LPG consumption has been growing at a much lower rate than could be expected from the huge increase in connections may be a result of these remaining financial constraints (Jain et al., 2018; Kar et al., 2019).[4] Hence, for households under severe financial constraints, the health information might still not make a difference. Whether or not health messaging increases LPG consumption under the new financial conditions yet remains to be tested.

2.5 Further drivers of LPG use

It is obvious that apart from our main variable of interest, i.e., health information, a host of other factors can be expected to influence the use of LPG. The energy transition literature, notably when it focuses on the use, rather than just the adoption of clean cooking technologies, suggests a number of factors that may be relevant in our context (see e.g. Masera et al., 2000; Heltberg, 2004, Hanna and Oliva, 2015). Along with income and education, the opportunity costs of fuel collection (e.g., Farsi et al. 2007; Gupta and Köhlin 2006; Hanna and Oliva 2015), and factors related to the social and cultural environment such as food taste preferences (e.g., Akpalu et al. 2011; Srinivasan and Carattini 2019) have been identified as relevant for the use of LPG. In the context of the Indian PMUY program, there has also been a discussion whether or not LPG use may simply increase over time after the initial acquisition of the stove (Jain et al., 2018; Sharma et al., 2019; Kar et al., 2019). This type of variables can be used to test the success of randomization and/or as controls when we analyze the effect of health information.

[4] At the same time the literature on fuel transition highlights that there is usually no direct switch from one fuel to another but a period of combined use where several fuels are stacked and some of them may only be used at the margin (van der Kroon et al., 2013; Masera et al., 2000). The simple adoption of a new cooking technology does hence not reveal much about the frequency of its use (Masera et al., 2000; Heltberg, 2004; Hanna and Oliva, 2015). This is also confirmed by initial studies on rural LPG uptake and use in India (Cheng and Urpelainen, 2014) and must be considered when examining drivers of increased LPG consumption.

The literature further suggests that there may be within-family differences in preferences for fuel choice, willingness to pay and reaction to health information, since women and children often lack decision power over the financial issues, but are at the same time most affected by indoor air pollution (Mobarak et al., 2012; Miller and Mobarak, 2013; Krishnapriya, 2017).

3 Conceptual framework

We propose an illustrative utility-maximization model to motivate and structure our analysis. Let the household's utility U be defined as a function of the cooking gas LPG (g) and a composite good (x). x includes traditional biomass for cooking such as firewood but also other consumption goods. To ensure a certain degree of both complementarity and substitutability between g and x we use a standard Cobb-Douglas utility function:

$$U(g, x) = g^{\theta} x^{1-\theta} \tag{1}$$

with $0 < \theta < 1$.

The parameter θ captures the preference for cooking gas as compared to the composite good, and we assume that it is non-zero since all households we consider opted for an LPG connection through PMUY, and stated that they would intend to purchase a refill at some point in the future. For an income level of B and prices p_g and p_x, the budget constraint is given as:

$$gp_g + xp_x \leq B \tag{2}$$

Solving the optimization problem yields the Marshallian demand for LPG:

$$g^*(p_g) = \frac{B}{p_g} \cdot \theta \tag{3}$$

This equation shows the household's optimal LPG consumption as a negative function of the LPG price p_g. We can invert this function to obtain an expression of the price the household is willing to pay as a function of the amount consumed, for given preferences and budget:

$$p_g(g^*) = \frac{B}{g^*} \cdot \theta. \tag{4}$$

The first (rather trivial) observation to note is that since $\frac{\partial p_g}{\partial g} < 0$, if a household is asked to consume more than g^*, the price it must pay will have to be reduced. What we are interested in here is how health information affects (1) the discount a household demands when asked to substantially increase LPG consumption and (2) the propensity of the household to actually increase consumption, when provided a pre-defined discount. Given the setting underlying our study, where all households still have considerable room for more frequent LPG use, a consumption increase of 100% is used to indicate substantially higher consumption.

In the following, we first develop the theoretical expectations for (1), i.e., the household's willingness to pay for LPG conditional on increased use (Section 3.1), and then derive the predictions for (2), the propensity to double gas consumption (Section 3.2).

3.1 WTP conditional on increased use

Let us consider that the preference for LPG θ is composed as follows: First, a basic preference $\bar{\theta}$ due to the convenience and time savings and other general benefits associated with cooking on the gas stove. Second, an additional appreciation based on the health benefits, reflecting knowledge of the health risks related to cooking with traditional biomass h, and the extent γ to which this knowledge is salient for the decision maker. In particular, the salience γ may vary based on the exposure to smoke from the traditional cookstove ("chulha"), and thus be higher for women than for men. Consequently, we define θ as:

$$\theta = \bar{\theta} + h \cdot \gamma \tag{5}$$

with $0 < h < 1$ and $0 < \gamma < 1$.

Now consider that we do not ask for the price households are willing to pay for their currently optimal—but very limited—consumption, but for a substantially increased consumption, namely a fixed $\bar{g} = 2g^*$. Including the specification for θ and this fixed consumption requirement into into Eq.(4), we obtain:

$$p_g(\bar{g}) = \frac{B}{\bar{g}} \cdot \theta(h, \gamma) = \frac{B}{\bar{g}} \cdot (\bar{\theta} + h \cdot \gamma) \tag{6}$$

Taking the derivatives of $p_g(\bar{g})$ with respect to h and the cross-derivative with respect to h and γ provides us with the relevant theoretical predictions $\frac{\partial p_g}{\partial h} > 0$ and $\frac{\partial^2 p_g}{\partial h \partial \gamma} > 0$ (for computational details, see Appendix A.1). We thus expect to find two effects: (i) a positive effect of the health information on the price the individual is willing to pay for LPG, and (ii) a positive interaction effect with salience, i.e., in particular, a greater effect of the health messaging on women than on men.

Equivalently, we can express these hypotheses in terms of the compensation required by the individual to increase LPG consumption from g^* to $\bar{g}$. The necessary compensation (C) corresponds to the market price of an LPG refill (p_m), which we can consider as given for our period of study, minus the price the individual is willing to pay (p_g), i.e., $C = p_m - p_g$. Hence, the effects with respect to the necessary compensation ($\frac{\partial C}{\partial h}$, and $\frac{\partial^2 C}{\partial h \partial \gamma}$) correspond to the above derivatives of $p_g(\bar{g})$ multiplied by (-1).

While our experiment allows us to test the effect of h, the evidence we can provide on γ is suggestive only, since our experiment was not designed to examine heterogeneous effects by gender. This will be discussed further in Sections 4 and 5.

3.2 The propensity of doubling gas consumption

Let us now consider actual change in consumption. This change can be observed through the use of a price-reducing voucher until a pre-defined, household-specific deadline. More precisely, the outcome variable of interest is the propensity of the household to use a voucher that ensures an increase of LPG consumption from g^* to $\bar{g}$, for any level of a randomly determined price reduction D and the resulting offer price $p_d = p_m - D$ specified on the voucher.

Let us denote voucher use by the indicator variable Y. Whether or not the voucher is used depends on the difference in utility ΔU between a situation in which the voucher is used U_1 and a situation in which it is not used U_0:

$$Y = \begin{cases} 1 & \text{if } \Delta U > 0 \\ 0 & \text{if } \Delta U \leq 0 \end{cases} \tag{7}$$

The difference in utilities itself reflects the (unobservable) propensity of voucher use. Taking into account the conditions for voucher use, namely doubling initial consumption and the discounted price p_d, ΔU can be expressed as:

$$\Delta U = U_1 - U_0 = \bar{g}^{\theta}(B - \bar{g}p_d)^{1-\theta} - g^{*\theta}x^{*1-\theta}. \tag{8}$$

To predict how the propensity to use the voucher will react to health messaging, and how this in turn is affected by the salience of this information for the decision maker, we again compute the derivative with respect to h and the cross-derivative with respect to h and γ. This yields the following results: $\frac{\partial \Delta U}{\partial h} > 0$ and $\frac{\partial^2 \Delta U}{\partial h \partial \gamma} > 0$ (see Appendix A.1).

The model thus predicts that, just as the WTP, the propensity to use the voucher (and hence the propensity to double consumption) should be positively affected by the health messaging, and this effect should again be greater for decision makers for which the health information is more salient, namely for women.

4 Empirical analysis

4.1 Sampling and survey implementation

We tested our hypotheses in the rural communities of Bikaner, a district in the state of Rajasthan in Western India. The selection was purposive as it fulfilled several criteria. Rajasthan was one of the first states to experience the launch of PMUY in May 2016. This gave the program a clear one year since its launch before our survey which started in October 2017.

Available statistics on fuel use indicate that the district is quite representative for other parts of rural India. In 2011, 13% of the rural population in Bikaner district used LPG as their main cooking fuel as compared to 11% in rural India as a whole. Only regarding the solid fuels that are used as an alternative, there are some differences. Given its dry climate and the related lack of vegetation, dung cakes are more often used in Bikaner relative to firewood (see Table 1). With respect to more general poverty-related indicators that may be relevant to fuel choice, Bikaner varies around the country average, with some factors above, and some factors below the all-India average. For instance, per capita income is almost equal to the national average, electricity is more widely spread in Bikaner than in the rest of India, while literacy rates are lower than average. The sex ratio is clearly below the Indian mean, which suggests that the status of women in the region is rather low.[5] There is, however, a general North-South divide with respect to this indicator, and the rate we find for Bikaner district is close to the rates for the large Northern Indian states such as Punjab (895) or Uttar Pradesh (912) (Government of India, 2013-14).

The sample consists of 550 households who received an LPG connection under the PMUY programme, but remained infrequent users. 55 villages were sampled from the census lists (Government of India, 2013-14) with probability proportional to population size. For each village, a simple random sample of ten households was drawn from the village lists of PMUY beneficiaries. On average, there where 133 PMUY beneficiaries living in each village in the sample. Power calculations and the sampling procedure are described in Appendix A.2.

[5] Low sex ratios indicate a high female abortion rate, a neglect regarding the female children's needs with respect to health and nutrition, and/or violence against women and girls (including female infanticide). For a discussion, see, e.g., Drèze and Sen (2013).

Table 1: Energy access and demographics Bikaner vs. India 2011

	Bikaner		India	
	Total	Rural	Total	Rural
LPG main cooking fuel	59%	13%	29%	11%
Firewood main cooking fuel	21%	54%	49%	63%
Dung cake main cooking fuel	16%	31%	8%	11%
Electricity for lighting (%)	86%	62%	67%	55%
Average literacy	65%	61%	74%	69%
Sex ratio (women per 1000 men)	905	903	943	949
Net domestic product p.c. (INR)	52263		53331	

Sources: Government of India (2013-14, 2012); Government of Rajasthan (2017); Directorate of Census Operations Rajasthan (2014)

The sampling strategy with many villages and relatively few households within each village was chosen to ensure that all interviews could be run in parallel so that spillover effects would be minimized. Households that were unavailable, impossible to trace or that turned out to be ineligible for our sample were dropped and replaced from a back-up list of replacement households at the time of the first visit to the village. No repeat visit was made to a village.

Within each household, the preferred respondent was the main cook, who is usually a female. However, men were accepted as respondents if the relevant women were unavailable or unable to communicate to the enumerators for cultural reasons. Eventually, there were about 10% male respondents in the sample (see Appendix A.3, Table A3). At the outset, preliminary screening questions were asked as follows:

1. Is the household indeed a PMUY beneficiary?

2. What is the frequency of use of cooking gas (LPG)?

These initial questions allowed us to screen out households that did not fit our criteria for infrequent use. We defined the corresponding threshold at a yearly LPG consumption of less than six cylinders a year for a family of five (excluding toddlers).[6] Thus, all PMUY households consuming less than 1.2 standard-size (14.2-kg) LPG cylinders per capita (for persons of age six and above) per year are considered infrequent consumers. Households covering all energy needs for cooking with LPG generally have a 50-100% higher consumption in the sampled villages (Desai and Vanneman, 2015).

The responses to these questions were verified by checking the entries in the respondents' official gas passbooks that report the households' average LPG consumption per year and the date of the purchase of the cylinder currently in use. This information allowed us to compute the expected time until the next refill would become due based on past consumption patterns.

It should be noted that a number of initially selected villages and individual households, had to be replaced in the sample: First, for some of the originally sampled villages, we were unable to obtain the list of PMUY beneficiaries. Second, in some villages, a very large number of households could not be traced as villagers were away for agricultural operations and had moved into so-called 'dhani', i.e., shelters in the fields scattered around the village and households. When this number became very high (crossed 30%), the whole village was replaced. Third, certain villages close to the India-Pakistan border were replaced due to security concerns. Eventually, the survey covered a total of 554 individuals from 55 villages.

Between September 2016 and March 2017 we carried out team building activities, some initial training of enumerators, a focus group discussion, pilots and key informant interviews, to understand the situation on the ground

[6] An average Indian family using LPG exclusively requires 10-12 cylinders per year (Kar et al., 2019).

and to refine our survey instruments. Subsequently, we established the cooperation with LPG distributors, requested the PMUY lists and analyzed secondary data sources from the Census and the National Sample Survey (NSS) as relevant for our sampling procedure. In October 2017 we conducted a final one-week intensive training workshop for the enumerators. The training included sessions on the rationale of the research design, exercises of the interviews including the implementation of the WTP-elicitation mechanism and the presentation of the different frames for the experiment (see below). It also included a familiarization of the enumerators with the use of the survey application 'Qualtrics' that allowed them to directly register all answers on electronic devices like tablets or smart phones. Based on this training, the enumerators—a team of students from Bikaner Agricultural University—carried out the data collection between October 2017 and February 2018. All household interviews were conducted in Hindi or Rajasthani (Marwari).

The survey had several domains. The first section inquired extensively on household demographic and socio-economic characteristics while the second part had specific questions to understand cooking and fuel use patterns. Subsequently, the survey application randomly assigned the health information to 50% of the households, while the others received some general information on LPG supply and its characteristics. Following this, the enumerators assessed the required compensation for an increased use of LPG. Finally, the survey included several questions to test whether the respondents understood the health information provided.

The experimental set-up and the mechanism used to obtain the value of the required compensation are described in detail below.

4.2 Experimental set-up

The intervention consisted in verbal information on the effect of traditional cooking on child development and diseases such as lung diseases, heart diseases and eye diseases. The enumerators were given a pre-formulated one-page text on these issues that they familiarized with and memorized in advance, so that they would keep their wording very close to the text without directly reading it out. All enumerators also carried along a colored plasticized picture card (size A4) with illustrations of the different diseases. The duration of the presentation of health hazards lasted for three to five minutes.

Given the possibility that any frame—or simply the time spent on talking about LPG—may affect the answers of the respondents (Haffert et al., 2017), we constructed an alternative non-health related (and in this sense 'neutral' or placebo) frame for the control group. This frame consists of information on how cooking gas is extracted or produced from crude oil and then distributed to the households. The information material again consists of a brief text presented by the enumerator and a visualizing picture card to illustrate the key messages. An English translation of the pre-formulated texts for both treatment and control group as well as a copy of the corresponding picture cards are presented in Appendix A.4. Randomization was automated through the app that directly displayed only one of the two frames to the enumerator.

By design, the comparison of households who receive the health information and households who receive the placebo treatment reflects the net effect of the health information. If communicating about LPG over a certain time indeed has an effect by itself, the gross effect of a health-information (encompassing the effect of both, the health-relevant content, and time of the LPG-relevant communication) should, in fact, be larger. As a consequence, our estimates of the treatment effect can be considered as a lower bound of the effect of health information for a population that would otherwise receive no LPG-related information at all.

After exposing the respondents to either of the two frames (health and non-health), we first assessed the households' stated WTP for LPG conditional on increased use and then observed households' actual consumption behavior through the use (or not) of the voucher. Details on the measurement of these outcome variables are provided in Sections 4.3 and 4.4.

4.3 WTP conditional on increased use

There are several procedures used in experimental economics to measure willingness to pay in a way that ensures that rational individuals will reveal their genuine preferences. We base our WTP assessment for LPG on the Becker-DeGroot-Marschak (BDM)-mechanism (Becker et al., 1964), a widely used option that mimics a Vickrey auction by replacing the other buyer with a random number. Under a common version of the BDM-method, the person states a *bid* (for a good to purchase). The bid is then compared to a randomly determined *offer price*, that is, the price at which the good is made available to the bidding person. If the person's bid is higher than the offer price, the item is sold at the offer price. If the bid is below the price, no transaction happens and no payment is made. In this context, revealing one's true willingness to pay through the bid is a strictly dominant strategy.

In a study on willingness to pay for water filters in northern Ghana Berry et al. (2019) demonstrated that the mechanism can be usefully applied even in contexts of low numeracy among the respondents. To ensure that our respondents really understand the process, we explained each step of the procedure and followed it up by carrying out two rounds of the BDM-mechanism with unrelated goods, first with a piece of soap, and then with a lighting bulb.

If the respondents' bid was higher than the offer price, they paid the offer price and received the goods. Hence, by the time the respondents reached the LPG assessment, they were quite familiar with the procedure and had experienced that the implications of their decisions were real and binding.

With respect to LPG, the implementation of the BDM-mechanism required adjustments due to the specific context of the study. First, real transactions with LPG cylinders are not possible, since LPG supply regulations in India imply that households can only purchase the refill from official distributors of oil marketing companies, and that, too, only once they have used and returned their empty cylinder. Hence, instead of concluding the transaction by selling an LPG cylinder at the reduced offer price to successfully bidding respondents, we handed out vouchers for the purchase of the next cylinder.

Second, we aim to elicit the WTP for LPG not as a good used only rarely for special occasions, but on a more regular basis, i.e., under the condition of *increased use*. This cannot be achieved simply by providing households with the offer to buy an additional cylinder. As our sample only includes households that plan to buy a refill at some point, over an infinite time horizon, all of them should be willing to purchase one at the market price p_m.

To obtain the relevant information on the WTP for increased consumption, the additional LPG use must be observable during a pre-specified period, i.e., before a certain deadline. As mentioned earlier, we chose a deadline relative to current use. More specifically, we fixed a specific deadline for each household that would require this household to consume the remainder of the LPG in the cylinder currently in use twice as quickly as under normal circumstances. The deadline was determined based on the information about the family's existing LPG consumption and the remaining time for using up the current cylinder using the information provided at the outset in the screening questions. If this estimate could not be meaningfully interpreted (for instance, because the LPG connection was established only very recently), the household was directly asked to make a prediction on when they would need a refill and this prediction was halved to replace the estimate. The next working day after the end of this period constituted the deadline determined for the validity of the voucher. This expiry date was clearly communicated to the respondent, and written on the voucher. We also monitored that it was respected later by the distributors by checking the dated receipts for the refills for which they were used.

We thus asked the respondents to make their bid for a new LPG cylinder under the condition to use up their current cylinder until the deadline. This bid was then compared to the randomly drawn discounted offer price p_d. The corresponding discount D over the market price p_m of 480 INR was designed to fall in the interval from 5 to 235 INR. Larger discounts were not expected to be necessary. The offer price itself was then between 245-475 INR, and drawn from number cards in front of the respondents (for details, also on the choice of the price range, see Appendix A.5.1).

When the respondents stated a WTP which was at least as high as the offer price, and hence the (offered) discount (D) greater than or equal to the required compensation for the increased use of LPG, they received the voucher, and they knew that they were expected to buy the next cylinder before the expiry date indicated on the voucher.

Unlike in the prior examples with the soap and the light bulb, we could, however, not enforce the final sale. This violates the conditions of the BDM-mechanism because stating a bid that reveals the true required compensation is then no more a strictly dominant strategy. Indeed, it does no harm to consumers to make a higher bid since anyway, if they bid high enough to get the voucher, they do not need to actually make use of it. At the same time, it does not make them any better off to make a higher bid than the one that corresponds to their genuine willingness to pay. Hence revealing the truth remains a weakly dominant strategy.

In any case, a rational respondent will never make a bid that is too low. If at all, WTP will hence be overestimated by the procedure we chose. This may add to the effect we could obtain due to the fact that people under both the health and the alternative frame were confronted with some discussion on LPG (see above). For both reasons, average WTP obtained in our survey can be considered as an upper bound of the respondents true WTP.

Note that the effect of the health-information treatment on WTP should not be affected by the enforcement problem. This is because there is no reason to believe that it might affect the treatment and the control group in different ways. As long as they are not affected in different ways, our experiment should yield an unbiased estimate of the net effect of health information on WTP.

4.4 Increase in LPG consumption

In the second part of our empirical analysis, we compare the actual voucher use by the households in the treatment and in the control group. Since the vouchers could be used only until the expiry date, the use of the voucher implies that the household truly consumed the remaining LPG in their current cylinder more quickly than usual, and that the incentive of the discount on the next cylinder was sufficiently strong to trigger this behavioral change. In addition, actual voucher use provides some insights into the sustainability of the initial impression made by the health information.

Two distinct factors should be considered in this context: First, while the health information is only transmitted to the mostly female respondent who also provides the statement on WTP, the choice to double LPG consumption or not is the result of an intra-household decision-making process involving several household members. The actual purchase is usually carried out by men. These family members (i) do not directly obtain the health information and (ii) may be less smoke-exposed than their spouses. Unless the information is transferred within the family very convincingly, this should reduce the effect of health messaging. Furthermore, the effect of health messaging should depend on the power of the respondent within the intra-household decision making process.

Second, over time, the impression of the health messaging may simply fade away. In the most extreme case, the health information could be fully forgotten, in which case the intervention would have a zero effect on voucher use. In contrast, sharing health information and discussing it among family members may also increase its influence on the purchasing decision due to further reflection upon the topic, and respondents may develop a stronger preference for LPG when they are continuously exposed to the toxic smoke from the chulha after having learned what it implies for their health. Depending on which of these causal channels dominates health information may have a stronger or weaker effect on actual consumption behavior. The effect may also be stronger or weaker than what the respondent's immediate reaction on WTP may lead us to expect.

5 Results

In a first step we test whether our randomization allows us to successfully split the sample into two groups that are similar in all aspects that could be relevant for WTP and voucher use. Table A1 in Appendix A.3 compares the means of both groups for a number of variables including socio-economic characteristics such as the respondent's age, education, religion, household size, the social category and proxies of income and wealth like assets and land ownership. Further variables describe the household's fuel choice and cooking behaviour and capture preferences for and access to LPG: The average consumption of LPG, distance to the LPG sales point (zero in case of home-delivery), perceived convenience of LPG, knowledge about LPG subsidies and stated barriers to regular LPG consumption such as high refill costs or safety concerns. Finally, there are variables directly related to the current LPG use and the conditions under which respondents were bidding such as the number of days until the voucher's expiry date (voucher validity) and the content of the current cylinder at the time of the survey. The comparison across groups indicates that across all 25 variables, none of the differences in means is statistically significant at the 10% level. This implies that potentially confounding factors are well balanced across the two experimental groups.

The same holds, if we limit the sample to those respondents who obtained a voucher (see Table A2): Apart from a small difference in the share of Hindus and Muslims, the two experimental groups only differ with regards to the WTP for LPG, which is a desired effect of our intervention. A description of all variables and summary statistics are provided in Appendix A.3.

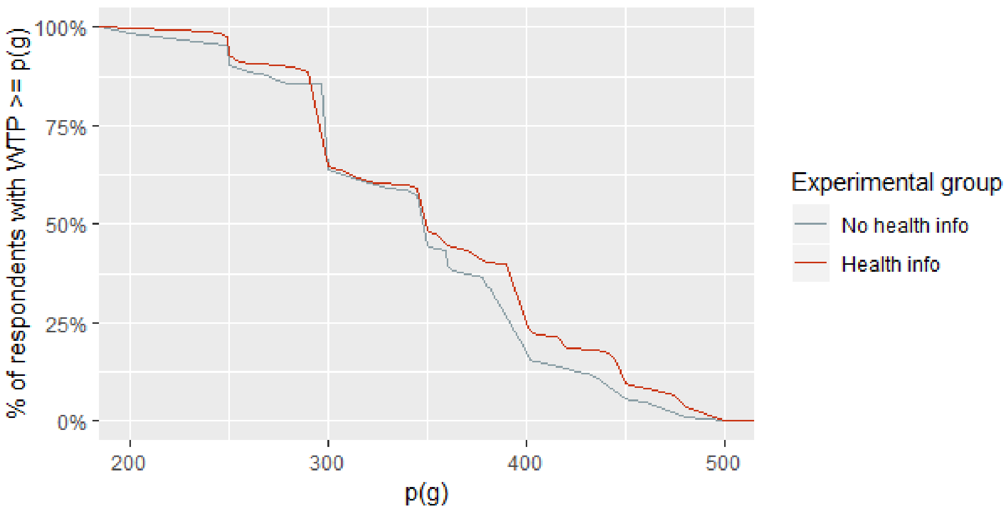
5.1 Impact on willingness to pay

Given the successful balancing of potentially confounding variables we can now compare WTP for the treatment and the control group. Overall, the health information leads to an average increase in WTP of about 10 INR (from 352 to 362 INR, see Table 2 below).

The effect is not large, but the intervention was only very short and carried out by enumerators that were strangers to the respondents. Under conditions of more sustained health messaging by trusted health workers or members of the local community, the effect might have been much stronger. Furthermore, remember that the estimate reflects the net effect of health messaging, and that the gross effect could be larger if the time of the communication on LPG has a positive effect by itself.

To provide some more details on this result, Figure 1 displays the cumulative distribution of the respondents' stated WTP in both treatment groups.

Figure 1: WTP for LPG conditional on increased use, by experimental group



The share of respondents accepting prices in the upper half of the price range is consistently higher among subjects who were confronted with the health information. Figure 1 also shows that the estimated median WTP is at 350 INR per cylinder. Since these estimates must be considered as an upper limit of the true WTP of our respondents (see Section 4.3), they are well in line with the results of an earlier large-scale household survey in six Indian states, which suggest that household who are interested in adopting LPG would be ready to pay 300 INR per month (median) for covering all cooking needs with LPG (Jain et al., 2018). While health information increases WTP, substantial additional subsidies will still be required to induce poor households to become more regular LPG consumers.

Apart from the direct effect of our intervention and the respondents' price-elasticity of demand, their stated WTP may be influenced by some additional factors. In particular, our previous discussion suggests that gender differences, due to differences in smoke exposure and time spent with cooking, should affect the impact of health information. It may also be relevant to control for the content of the current cylinder and the time left until the voucher needs to be used. Few households had a full cylinder at the time of the survey, such that the requirement to speed-up consumption referred to different absolute quantities. Households might agree to a lower compensation when their cylinder is already partly used. Similarly, the absolute time period over which the behavioral change to double LPG consumption is required, varies between households. Due to differences in the usual speed of consumption, this may be true even if the filling of the cylinders is initially the same for two households. In principle, this could have implications for WTP, too.[7]

[7] For instance, households might feel that a behavioral change over a small period of time—maybe just a few days—is easier to achieve than a change over many weeks. In

Whether these considerations do affect the respondents' stated WTP, and if so, in which direction, will be examined below. We will also add further controls for potentially relevant household characteristics.

5.1.1 Multivariate regression analysis for WTP

Table 2 presents the results. As a baseline, Column 1 shows the effect of the health treatment without any other variables, as already discussed in the previous section. In Column 2 we examine heterogeneous treatment effects by gender, and thus introduce a dummy variable for male respondents and its interaction with the treatment variable.

As mentioned already, there are only few male respondents in our sample and they systematically differ from average men in the communities of interest. In most cases, these men belong to very traditional families as they did not allow their spouses to talk to the enumerators. This also suggests a highly unequal balance of power in these households. Our estimations related to gender effects must therefore be interpreted with caution. Nevertheless, gender differentiation appears interesting enough for us to systematically present whatever evidence we have. However, rather than to understand our estimations as final results, they should be seen as suggestive evidence calling for verification through future research. Whatever the particular selection of men among our respondents, the results in Column 2 correspond to our expectations.

this case WTP should be higher if the survey happens closer to the date at which the next refill would have been required anyway. However, one could also imagine that having more time enables the household to plan the increased consumption in a better way, i.e., by using LPG rather than the chulha when many guests are in the house, which may not happen that frequently. Moreover, time preference would imply that a compensation to be received in the far away future would be valued less than a payment one could receive within a few days.

Table 2: Treatment effect on WTP, including controls

	(1)	(2)	(3)	(4)
Health information	10.237*	13.777**	12.175**	13.166**
	(0.065)	(0.013)	(0.036)	(0.046)
Male		31.863**	54.111***	42.714**
		(0.014)	(0.001)	(0.014)
Health information X Male		-41.385*	-62.277**	-53.083*
		(0.072)	(0.020)	(0.068)
Voucher validity			-0.283	-0.298
			(0.178)	(0.199)
Content			4.245	5.845
			(0.766)	(0.698)
Asset index				0.342
				(0.906)
Land				15.647**
				(0.029)
LPG distance				-0.170
				(0.673)
Fin. restriction				-14.355
				(0.172)
Education				3.402
				(0.289)
Age				-0.341
				(0.316)
Household size				-0.853
				(0.574)
Months since LPG adoption				-0.191
				(0.645)
Constant	351.678***	348.846***	352.230***	366.083***
	(0.000)	(0.000)	(0.000)	(0.000)
adj. R^2	0.003	0.008	0.017	0.019
N	539	539	468	455

p-values based on standard errors clustered at village level in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

Note that due to the inclusion of the interaction term, the coefficient estimate for health information now refers to female respondents alone. With a point estimate of about 14 INR it is higher than the average for all respondents (male and female) in Column 1. Correspondingly, the negative coefficient of the interaction term suggests that men react to health messaging much less than females. For men alone, the effect of health messaging is insignificant in our sample (not shown). The main effect of the dummy for male respondents further indicates that within our sample, men generally state a much higher WTP than women. This seems to be a common result for WTP assessments in households in which women are not used to commit to major payments, and does not specifically relate to LPG (see also Beltramo et al. (2015)). In our sample, only 3% of the women report taking decisions on the purchase of durable goods on their own.

Column 3 then adds controls for the remaining content of the cylinder at the time of the survey, and the period of validity of the voucher. None of the two are significant. This suggests that neither of the two play a major role in determining the compensation for increased consumption requested by the household. Rather, households seem to just consider the required change in behavior in terms of the relative increase in consumption, no matter the period over which this change is requested, and no matter how much the absolute quantity of LPG consumption this implies.

Column 4 further adds a number of other control variables that might be relevant for the willingness to pay. The only significant variable is land, reflecting that wealthier households owning some land tend to have a higher WTP. Note that the effects of the control variables (or the lack thereof) should not be over-interpreted as some of them are highly correlated. They are included mainly to show the robustness of the main results. The estimated treatment effect remains positive and significant throughout (with little change in size across Columns 2-4 in which it refers to females). The sign and significance of gender differences also remain robust, albeit with considerable variation in the effect size, which is due to the lack of precision given the small number of men in our sample.

5.2 Impact on voucher use

So far, the results thus confirm our hypotheses. But is the voucher that allows the household to buy the next LPG cylinder at or below the price of reported WTP actually used? Does it indeed lead to the requested behavioral change of doubled consumption until the given deadline?

Remember that there are several reasons why this may not necessarily be the case: First, using the BDM-mechanism with a voucher rather than a direct purchase, WTP may be overstated. Second, respondents on WTP were mainly women who do not seem to have much influence on actual purchases. Third, the effect of talking about LPG and its health benefits may fade over time. And fourth, independently of the household's preferences, remaining supply constraints in Bikaner's rural villages may in some cases prevent a household from making the purchase before the deadline, even if it wishes to do so. In the following, we will thus examine the effect of health information on voucher use directly.

Overall, in 303 out of 539 conducted BDM-procedures, the respondent's bid (i.e., stated WTP) was sufficiently high to receive a voucher. The voucher values, i.e. the discounts offered on the purchase of the next LPG cylinder, range from 5 to 235 INR, about 70 % of them lie above 150 INR. For 296 vouchers handed out to households we could trace whether the beneficiary had used the voucher to cover a part of the household's next LPG purchase.

It turns out that only 35% of these 296 households actually used the voucher. Unfortunately, we are unable to disentangle the different possible reasons discussed above, and any combination of these could be responsible for this result. What we can examine, however, is the extent to which our intervention, namely the health messaging, affected the actual use of the voucher.

5.2.1 Effect of health info on voucher use among voucher owners

As in our analysis of WTP we proceed with regressions starting with a simple bivariate estimation of the treatment effect and progressively adding more variables. Table 3 presents the results using linear probability models (rather than probit or logit models) for ease of interpretation.[8]

Based on the 296 available observations, we find a strong and significant effect of health information on voucher use: The probability that a household uses its voucher is 11 percentage points higher for households that received the health information (41 vs. 30%, see Column 1). This corresponds to an increase by more than one third. The effect is even more remarkable given the time passed after the treatment, and the required intra-household transfer of the information. In addition, since spill-overs between treatment and control group cannot be avoided during the time until voucher use, this result represents a lower limit of the actual effect. Finally, as before, we should remember that we only estimate the net effect of health messaging, not including the possible impact of LPG-related communication time, which was the same for both treatment groups.

[8]Running the same estimations using probit models leads to very similar results that are even more precise (results available on request).

Table 3: Treatment effect on voucher use, including controls

	(1)	(2)	(3)	(4)
Health information	0.111**	0.075	0.108*	0.136**
	(0.046)	(0.200)	(0.084)	(0.029)
Male		-0.025	0.000	0.082
		(0.824)	(1.000)	(0.571)
Health information X Male		0.466***	0.404**	0.314
		(0.006)	(0.047)	(0.144)
Voucher validity			0.000	0.000
			(0.875)	(0.985)
Content			-0.168	-0.192
			(0.316)	(0.264)
Asset index				0.016
				(0.459)
Land				0.046
				(0.474)
LPG distance				0.005
				(0.130)
Fin. restriction				0.101
				(0.123)
Education				0.001
				(0.982)
Age				-0.004
				(0.303)
Household size				-0.025*
				(0.065)
Months since LPG adoption				0.008
				(0.101)
WTP for LPG				-0.001**
				(0.027)
Constant	0.300***	0.303***	0.345***	0.726***
	(0.000)	(0.000)	(0.000)	(0.002)
adj. R^2	0.010	0.033	0.029	0.065
N	296	296	254	247

Linear probability models, * p<0.1, ** p<0.05, *** p<0.01

p-values based on heteroskedasticity consistent standard errors in parentheses.

Columns 2-4 add a differentiation by the gender of the respondent and further controls. In contrast to theoretical expectations, it seems that the positive and significant overall effect is now primarily driven by the few male respondents in our sample. The interaction term is strong and significant in two out of three regressions. Furthermore, for men alone, the treatment effect is always positive and significant (not shown), while this is not the case for female respondents. This is surprising since the male respondents in our sample initially did not seem to react to the treatment—as measured by their statement on WTP.

This suggest some interesting dynamics after the visit by our enumerators. Due to their lack of power within the household, women seem to have more difficulties to transform their initially voiced preferences into the household's final purchasing decision. Hence, even if their greater smoke exposure leads them to react more strongly to health information in the first place, they may not always be in a position to actually push for a greater use of LPG. Men, once convinced, do not have this problem. At the same time, they seem to require more time to react to the health information received. They might first cross-check this information and/or discuss the issue within the family and with friends. This suggests that at given power relations within rural Indian households, it is important to convince men about the health benefits of LPG, and not just women. Unfortunately, we did not have the opportunity to check this explanation through additional qualitative investigations. Furthermore, it is is possible that some of the effect we observe is driven by the special selection of men in our sample.

Regarding the control variables, there is no surprise. As before, most of them are insignificant, this time including the indicators we use for wealth and income. This is consistent with our model since the budget is as relevant for U_0 without the voucher as for U_1 with the voucher and hence cancels out for ΔU (see Appendix A.1.2). Only household size has a negative and significant coefficient, and of course WTP, as the latter is negatively related to the discount amount by design. Households obtain the vouchers only if their stated WTP is higher than the randomly drawn, discounted offer price. Hence, the higher this price (i.e., the lower the discount D), the higher must be their WTP for them to be at all included in the sample.

The latter also leads to a more general risk of selection bias, even when we control for WTP. The average WTP in the sub-sample of voucher owners is significantly higher than the WTP of those respondents who did not receive a voucher (390 vs. 314 INR). As a result, the sub-sample may not be representative of our initially drawn sample of typical PMUY users.

This problem also affects our estimate of the treatment effect. As the health information affects WTP, it also affects the selection into the sub-sample of voucher owners. Studying the treatment effect within this sub-sample will thus not provide us with a valid estimate for the full impact of our intervention.

5.2.2 Joint effect of health information on voucher use

In order to avoid the selection problem discussed above, we additionally estimate the *joint* effect of health information on voucher use. That is, we now use the total sample of respondents, no matter whether they obtained a voucher or not, and set the outcome variable “voucher use” to zero for those respondents who did not receive a voucher in the first place (as their WTP was below the randomly drawn offer price). The share of voucher users in the total sample of households in our sample is now 20% (among voucher owners only, it was 35%). We use a fixed effect for each offer price, as the chance to obtain a voucher with a given WTP increases with decreasing offer prices. The fixed effects will thus provide a substantial part of explanation for the zero-values in the outcome variable.

Table 4 shows the results from a linear probability model estimation of the joint effect of health information on the probability to make use of a discount voucher.[9] Without offer-price fixed effects, the probability of a household to use a voucher (and thus to demonstrate doubled consumption) increases from 17 to 23% if a member of this household is confronted with health information. This corresponds to an increase by 35 percent. While the absolute value of the increase is thus smaller than in the sub-sample of voucher owners (6 as compared to 11 percentage points), in relative terms, the increase is as important as before. When we include offer-price fixed effects, the estimator becomes more precise.

In terms of heterogeneous treatment effects the results tend in the same direction as before, but the interaction term is smaller and remains insignificant. Yet, again, the effect for male respondents is very strong (24% in Column 3 and 19% in Column 4) and consistently significant (not shown), as opposed to the effect for female respondents that is significant only in Column 4.

This confirms the previous evidence. If we believe that the particular selection of men within our respondents is in any way meaningful for the rest of the population, this again suggests that men, too, are responsive to health information, and that it is important to convince them at least as much as their spouses.

[9] Probit model estimations provided on request.

Table 4: Joint effect of health information on voucher use

	(1)	(2)	(3)	(4)
Health information	0.058*	0.067**	0.054	0.085**
	(0.094)	(0.047)	(0.117)	(0.029)
Male			0.052	0.123
			(0.543)	(0.279)
Health information X Male			0.189	0.098
			(0.173)	(0.561)
Content				-0.115
				(0.203)
Voucher validity				-0.000
				(0.822)
Asset index				0.011
				(0.375)
Land				0.024
				(0.539)
LPG distance				0.004*
				(0.087)
Fin. restriction				0.034
				(0.452)
Education				0.006
				(0.728)
Age				-0.003
				(0.208)
Household size				-0.016**
				(0.017)
Months since LPG adoption				0.003
				(0.318)
Offer price fixed effects	No	Yes	Yes	Yes
Constant	0.169***	0.337***	0.325***	0.396**
	(0.000)	(0.004)	(0.004)	(0.011)
adj. R^2	0.003	0.081	0.091	0.100
N	532	531	531	449

Linear probability models, * p<0.1, ** p<0.05, *** p<0.01

p-values based on heteroskedasticity consistent standard errors in parentheses.

While we have so far used fixed effects to account for differences in the randomly drawn offer price, we can also include the offer price p_d directly as an explanatory variable. While this constrains its impact to a linear effect, it allows us to more easily interpret the corresponding coefficient estimates. Appendix A.5.2 shows the results. In line with the predictions of our model (see Appendix A.1.2) we find that price reductions have a positive effect on the household's purchasing decision (see Table A4). A discount of 50 INR increases the probability of voucher use by about 10 percentage points, which is similar to the estimated impact of our brief health information (11 percentage points in the corresponding model with all controls; see Table A4, Column 4). The latter remains stable across the range of discount values (see Figure A5). This implies that health information and price reductions can be combined to yield the sum of the individual effects. They neither interfere with each other, nor are there any complementarities.

5.3 Testing the information channel

While we argue that the success of the intervention is based on the respondents' greater health awareness, this has not been directly tested so far. In this last part we will thus assess the effect of the health-messaging on health-related knowledge. To that aim we compare post-intervention responses to several questions regarding the health hazards related to traditional cooking from the treatment group with those of the control group.

First, we examine the response to the question whether traditional cooking affects health slightly, severely, or not at all. Our dependent variable is a binary indicator of the believe that there are serious health hazards implied. The relationship between the health information and the reported awareness of serious health hazards is highly significant and strong. Without any further information, respondents knew very little about health hazards related to smoke from the chulha, leaving much scope for improvement: under the alternative frame, only 13% believed that there are serious health hazards related to cooking with traditional biomass. This was also confirmed in complementary qualitative interviews with other households. When women were asked about health effects, they primarily thought of these as temporary irritations such as cough or watering eyes, and stated that these were not problems of any major consequence, but rather something to get used to over time. In contrast, among respondents that received the health information, 48% report to be aware of serious adverse health effects, i.e., reported awareness is four times as high as before.

Table 5, Column 1 presents these results distinguishing by gender. Among female respondents, 12% of the untreated report that they are aware of severe health issues as compared to 46% (12+34%) of the treated.

Table 5: Treatment effect on health-awareness

	(1) Severe effects	(2) IAP diseases	(3) All diseases
Health information	0.343***	0.150***	0.066***
	(0.000)	(0.000)	(0.000)
Male	0.132	-0.176***	-0.115***
	(0.123)	(0.000)	(0.000)
Health information X Male	0.157	0.029	0.023
	(0.181)	(0.590)	(0.570)
Constant	0.118***	0.280***	0.482***
	(0.000)	(0.000)	(0.000)
adj. R^2	0.160	0.096	0.084
N	503	539	539

* p<0.1, ** p<0.05, *** p<0.01

p-values based on standard errors clustered at village level in parentheses.

The men in our sample respond more frequently that they are aware of severe health hazards, but the difference to women is not significant. The interaction effect is not significant either suggesting that the effect of health messaging on health knowledge does not differ by gender. Results are robust to the addition of additional control variables (not shown).

Of course the treatment effect of the health message may be partly due to social-desirability bias: after the information treatment, respondents know that a positive answer is expected and might hence pretend awareness of severe health hazards even without fully understanding or being really convinced.

We thus consider a second dependent variable, which requires concrete knowledge about health hazards incurred when using traditional solid fuels for cooking. This variable reflects the share of diseases related to indoor air pollution (IAP) correctly identified within a set of ten diseases out of which only six are indeed related to IAP. Column 2 presents the results. They confirm those of the previous estimation. Our brief health information increases the share of correctly identified smoke-related diseases by 15 percentage points for females—and similarly for males since the interaction term is very small and statistically insignificant. Independently of the health messaging, in our sample, female respondents generally recognize diseases related to traditional cooking substantially better than male respondents.

As a third dependent variable, we examine the share of correctly identified diseases among all ten diseases. A value of one of this variable implies that not only the IAP-related, but also the IAP-unrelated diseases are correctly identified. This ensures that high values on the dependent variables cannot be obtained simply by responding in a way that relates all kinds of diseases to cooking habits. Hence the values of this variable cannot be driven by social-desirability bias. When using this variable, the treatment effect is smaller (only about 7 percentage points), but remains highly significant (see Column 3). Again the treatment effect does not differ between male and female respondents, i.e., there is no gender difference regarding the capacity to absorb the health information we provide. But again, overall, women recognize the relevant diseases substantially better than men. Unless this is driven by the particular selection of men in our sample, this gives some plausibility to our assumption that women who are exposed to smoke on a daily basis my find the knowledge about smoke-related diseases more important than men. In any case, this could explain why they tend to be somewhat better informed already prior to our intervention.

In sum, the empirical evidence thus confirms that the intervention increases the respondents' knowledge about the health hazards related to traditional cooking. Despite some differences in initial knowledge, this is true for both women and men, with no observable difference in the treatment effect, at least within our sample. This implies that gender differences in the impact of the treatment on WTP and voucher use cannot be explained by differences in the capacity to absorb the information we provide. This is in line with our theoretical argument, which suggests that gender differences are driven by differences in the salience of the information, rather than by the information itself. Of course, as we have seen, such differences may be overridden by practical constraints related to the limited power of females in household decision making over expensive items.

6 Conclusion

Traditional cooking habits based on the use of solid fuels such as cow dung and firewood generate severe health hazards. In India, the health burden from traditional cooking is particularly high. This paper examined to what extent health information for poor rural households can mitigate the problem. Based on a survey in rural Bikaner district (Rajasthan), we analyzed the effect of a health-information intervention on willingness to pay and the propensity to consume more LPG, a clean fuel, which all of our sample households already have access to in principle through the Indian government's PMUY program.

Our results show that health information increases the reported willingness to pay for LPG, and substantially increases actual consumption among households who currently use LPG only on a very infrequent basis. We measure this based on a voucher, which can only be used if LPG consumption is doubled until a certain deadline. Households exposed to health messaging, use the voucher about 30% more often than households exposed to a placebo treatment. We further show that the impact of our very brief, but concrete health messaging is as strong as a decrease in the price of a new LPG cylinder by about 50 INR.

Obviously, health messaging does not need to be considered as an alternative to price reductions. Our results confirm prior studies indicating that the willingness to pay for regular LPG use by a typical poor rural household is considerably below the current regulated market price of 480 INR per cylinder. It may thus be useful to combine health messaging and price reductions. We find that they neither interfere with, nor reinforce each other, so that any combination of both measures should simply yield the sum of the individual effects.

Our results also confirm that the health messaging indeed increases the respondents' knowledge about smoke related diseases, which is an important precondition for the causal effect we claim. It should be noted that without any health information, the relevant knowledge is extremely low. Among the untreated, only 13% of all respondents believe that cooking with traditional biomass entails any serious health risks. This percentage increases to 48% in the treatment group. The low initial knowledge may be one reason why we find such substantial effects on LPG use.

Beyond the general effects, our study suggests some heterogeneous treatment effects for male and female respondents. In line with theoretical expectations about the gender-specific salience of cooking related health hazards, female respondents react much more strongly to health information than the male respondents in our sample, when it comes to their stated willingness to pay. However, the estimated treatment effect on voucher use is greater for male than for female respondents. This suggests that until the final purchase of the next LPG cylinder, some interesting intra-household dynamics may be at play. Women often lack decision-making power on major purchases, and they may not always be able to convey the relevant health information obtained during the treatment to their husbands. This suggests that in order to obtain an actual increase in LPG consumption, health messaging should focus on men as much as on women.

We highlight these gender-specific outcomes here, because we believe that they may be important. However, it should be noted that our study was not initially designed to estimate heterogeneous treatment effects. In particular, the number of men in our sample is small, and they are certainly not representative for the male population in rural India. Further research is required to test the validity of these results.

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A Appendix

A.1 The model in detail

In this paper, we proposed an illustrative model based on the Cobb-Douglas utility function:

$$U(g, x) = g^{\theta} x^{1-\theta} \tag{1}$$

where g is the cooking gas LPG, x is a composite good that includes traditional biomass and other goods, and $\theta \in [0, 1]$ is an indicator for the preference for LPG as compared to the composite good.

For an income B and prices p_g and p_x, the budget constraint is:

$$gp_g + xp_x \leq B \tag{2}$$

Maximizing (1) subject to (2) yields the Marshallian demand function for LPG:

$$g^*(p_g) = \frac{B}{p_g} \cdot \theta \tag{3}$$

Inverting this function we obtain the price a household is willing to pay for this quantity of LPG:

$$p_g(g^*) = \frac{B}{g^*} \cdot \theta. \tag{4}$$

A.1.1 Predictions related to WTP

Imagine we request the household to increase its consumption from g^* to $\bar{g} = 2g^*$ as we are interested in the WTP for regular rather than very sporadic users. Assume that such a doubling of LPG consumption is feasible within the budget constraint (Assumption 1, see Section A.1.3). To make this situation again optimal for the household, the new price must be 50% lower than the initial price:

$$p_g(\bar{g}) = \frac{B}{\bar{g}} \cdot \theta = \frac{1}{2} \cdot p_g(g^*). \tag{5}$$

While this exact relationship is directly related to the restrictive assumption underlying the Cobb-Douglas utility function that the price-elasticity of demand is equal to 1, even otherwise, we would clearly expect a reduction in WTP with an increase in the requested amount to be consumed.

More interesting in the context of our study, however, is the question to what extent health information can compensate some of this reduction in WTP. What is the change in WTP if we increase the decision maker's knowledge about the adverse health effects of cooking with traditional biomass?

Let us consider the preference for LPG θ as a linear function of health knowledge $h \in [0, 1]$:

$$\theta = \bar{\theta} + h \cdot \gamma \tag{6}$$

where $\bar{\theta} \in [0, 1]$ is basic preference (e.g., due to the convenience and time savings associated with LPG) and $\gamma \in [0, 1]$ is a factor reflecting the salience of health information, notably due to gender.

We can then rewrite $p_g(\bar{g})$ as:

$$p_g(\bar{g}) = \frac{B}{\bar{g}} \cdot (\bar{\theta} + h \cdot \gamma) \tag{7}$$

The expected effect of health messaging on WTP is then given by:

$$\frac{\partial p_g}{\partial h} = \frac{B}{\bar{g}} \cdot \gamma > 0 \tag{8}$$

We are further interested to see if the impact of health messaging is affected by differences related to gender reflected by differences in the salience of the health information. To see this we need to take the cross-derivative with respect to h and γ. To do so, note that factors such as gender already influence the initial value of g^* and thus also $\bar{g}$. More formally, we can write:

$$\bar{g} = 2g^*(p_m, \bar{\bar{\theta}}) = 2\frac{B}{p_m} \cdot (\bar{\theta} + \bar{h} \cdot \gamma) \tag{9}$$

where p_m is the original market price and $\bar{\bar{\theta}} = \bar{\theta} + \bar{h} \cdot \gamma$ the initial preference for LPG. In other words, $\bar{g}$ is fixed as the double of the optimal consumption at the general market price and the initial preference for LPG $\bar{\bar{\theta}}$ that is based on the initial health knowledge and salience. We keep h fixed at this initial level $\bar{h}$ as its change due to the treatment does not influence g^*. In contrast, a greater salience of such health knowledge γ already influences the initial g^*. Hence, $\bar{g}$ needs to be considered as a function of γ but not of h when we take the derivatives. We assume that the treatment itself does not affect γ (Assumption 2, see Section A.1.3), which is obvious if we think of it as reflecting the gender of the decision maker.

Inserting (9) in (8) and taking the derivative with respect to γ, we obtain:

$$\frac{\partial^2 p_g}{\partial h \partial \gamma} = \frac{\bar{\theta} p_m}{2(\bar{\theta} + \bar{h}\gamma)^2} > 0 \tag{10}$$

A.1.2 Predictions related to the propensity of voucher use

The propensity to use the voucher can be expressed as the difference in utility ΔU between a situation in which the voucher is used U_1 and a situation in which it is not used U_0. Taking into account the conditions for voucher use, namely doubling initial consumption and the discounted offer price p_d we can specify U_1 as

$$U_1 = \bar{g}^{\theta} x^{1-\theta} = \bar{g}^{\theta} (B - \bar{g} p_d)^{1-\theta} \tag{11}$$

In contrast, the utility when the voucher is not used U_0 simply corresponds to Eq.(1) evaluated at the optimal level of consumption given the market price p_m, without any discount but with the possibility to freely adjust all quantities to changes in θ:

$$U_0 = g^{*\theta} x^{*1-\theta} \tag{12}$$

ΔU can thus be rewritten as

$$\Delta U = U_1 - U_0 = \bar{g}^{\theta} (B - \bar{g} p_d)^{1-\theta} - g^{*\theta} x^{*1-\theta}. \tag{13}$$

To facilitate the computation of the derivatives we simplify Eq. (13) through a monotonous transformation using logs. This transformation will leave the sign of the derivatives unchanged.

$$\begin{aligned}
\Delta u &= \ln U_1 - \ln U_0 \\
&= (1-\theta) \ln \frac{B - 2g^*(p_m, \bar{\bar{\theta}}) p_d}{B - g^*(p_m, \theta) p_m} + \theta \ln \frac{2g^*(p_m, \bar{\bar{\theta}})}{g^*(p_m, \theta)} \\
&= (1-\theta) \ln (1 - 2\bar{\bar{\theta}} \frac{p_d}{p_m}) - (1-\theta) \ln (1-\theta) + \theta \ln (2\bar{\bar{\theta}}) - \theta \ln \theta
\end{aligned} \tag{14}$$

Replacing θ by (6) and taking the derivative with respect to h yields:

$$\frac{\partial \Delta u}{\partial h} = -\gamma \ln \left(\frac{1 - 2\bar{\bar{\theta}} \frac{p_d}{p_m}}{2\bar{\bar{\theta}}} \right) + \gamma \ln \left(\frac{1-\theta}{\theta} \right) > 0 \tag{15}$$

Note that this computation is again based on Assumption 1 (a doubling of consumption is feasible within the budget constraint), or else, we would take the log of a negative quantity in the first term. A further relevant assumption is that the requirement to double LPG consumption in order to use the voucher is a binding constraint (Assumption 3, see Section A.1.3). For more extreme preferences for LPG, the model would suggest that the household would forego the voucher in order to be able to consume more LPG. This situation is irrelevant in practice, as the voucher can also be used any time before the deadline, and hence there is no constraint on the maximum use of LPG. For reasons of simplification, the model has not been designed to cover these obvious cases where the health treatment is extremely effective. Finally, remember that $0 < \frac{p_d}{p_m} \leq 1$ since p_d is the discounted price while p_m is the market price. Considering all these arguments, we obtain the sign of the derivative.

We now examine how the impact of h on Δu varies for different levels of the salience of health information. We use (15) evaluated at the initial preferences for LPG $\theta = \bar{\bar{\theta}}$. Considering that $\bar{\bar{\theta}} = \bar{\theta} + \bar{h} \cdot \gamma$ we can take the derivative of $\frac{\partial \Delta u}{\partial h}$ with respect to γ to obtain the cross-derivative:

$$\frac{\partial^2 \Delta u}{\partial \mathrm{h} \partial \gamma} = \ln \left(\frac{2\,(1-\bar{\bar{\theta}})}{1 - 2\bar{\bar{\theta}}\frac{p_d}{p_m}} \right) + \gamma \frac{h \cdot (2\frac{p_d}{p_m} - 1)}{(1 - 2\bar{\bar{\theta}}\frac{p_d}{p_m})(1-\bar{\bar{\theta}})} > 0 \tag{16}$$

This inequality holds under exactly the same conditions as the inequality in (15).

Before concluding this analysis, let us further examine the reaction of Δu to a change in the discounted offer price p_d. Since this price can be obtained only when the household effectively uses the voucher, a lower p_d makes voucher use more attractive:

$$\frac{\partial \Delta u}{\partial p_d} = -\frac{(1-\theta)2\theta}{(1-2\theta)p_m} < 0 \tag{17}$$

This inequality only requires Assumption 1 (see Section A.1.3). The negative relationship between WTP and the required consumption is thus also reflected in the lower propensity of voucher use (implying the doubling of consumption) for higher p_d.

Finally, note that—as opposed to WTP—the propensity of voucher use is unrelated to the budget B, since it enters in the same way in both U_1 and U_0 and hence cancels out:

$$\frac{\partial \Delta u}{\partial B} = 0 \tag{18}$$

A.1.3 Assumptions

This section provides an overview of the three main assumptions referred to above:

1. Doubling LPG consumption (as imposed in the experiment) is theoretically possible, i.e., the consumption of other goods does not fall below 0, for all possible prices $p_d \in [0.5p_m, p_m]$ and θ. Formally,

   $$B - 2g^*(p_m, \theta) \cdot p_d > 0, \forall p_d, \forall \theta$$

   Using Eq.(3) this further implies: $1 - 2\theta > 0, \forall \theta$.

2. The treatment $d \in [0, 1]$ does not alter γ directly, i.e., health messaging only affects health knowledge h, but not the salience of this knowledge:

   $$\frac{\partial \gamma}{\partial d} = 0$$

   This is certainly true for the main variable we think of in this context, namely gender, but also smoke exposure more broadly, which cannot change immediately, i.e., prior to the household's reactions with respect to consumption or stated WTP that we are assessing here.

3. The preference increase for LPG as a result of the intervention is not so strong that the household would want to increase its LPG use by more than 100%. This implies that the requirement we impose on the household to *at least double* its LPG consumption can be treated in the model as a requirement to *double* consumption:

$$\bar{g} = \max\{2g^*(p_m, \bar{\bar{\theta}}), g^*(p_d, \theta)\} = 2g^*(p_m, \bar{\bar{\theta}}) \Rightarrow 2\bar{\bar{\theta}} > \theta$$

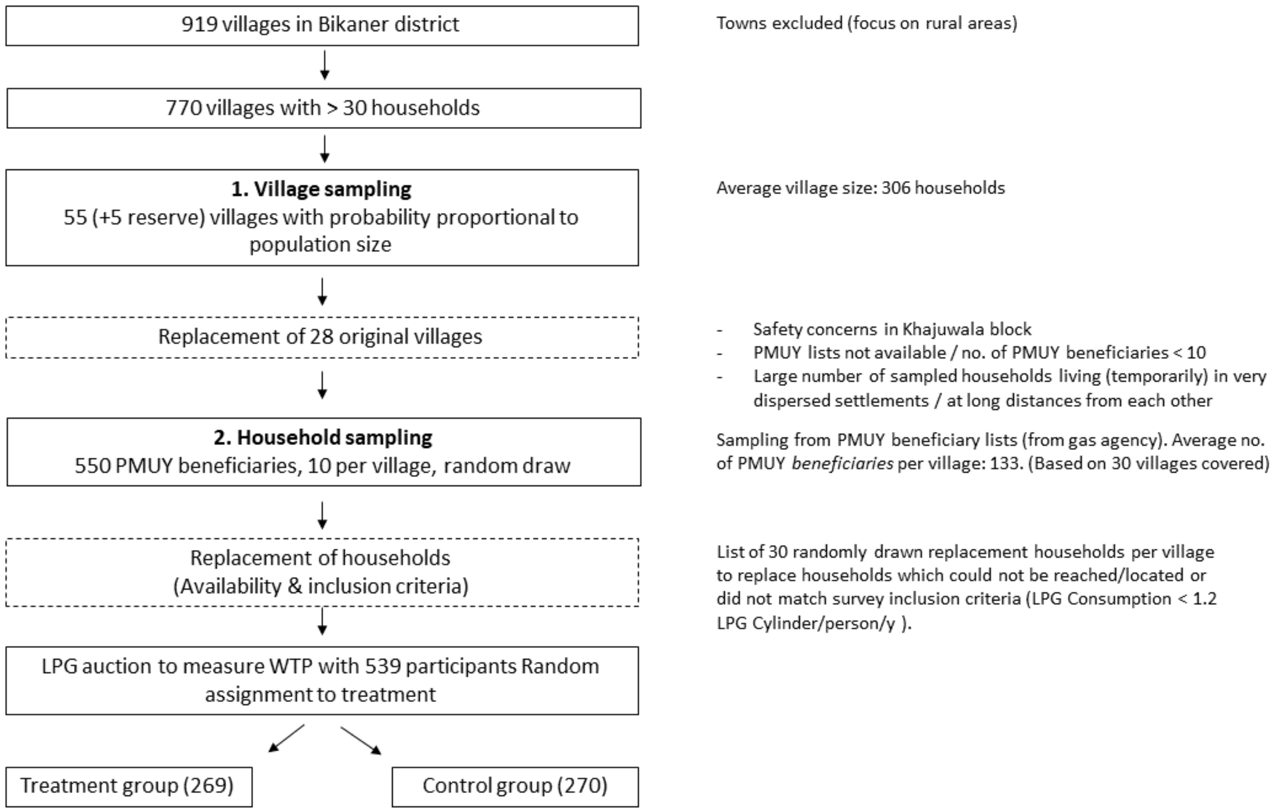
The alternative case is of course possible, but including this option into the model would make the model more complex, while not changing anything substantially. This is because households willing to consume more than $2g^*(p_m, \bar{\bar{\theta}})$ will have an even higher propensity to use the vouchers.

A.2 Power calculation and sampling protocol

We determined our sample size based on the aim to detect an additional WTP for LPG associated with the intervention of 12 INR or larger.

12 INR corresponded to 2.5% of the regulated market rate for a standard size LPG cylinder when the fieldstudy started (= 480 INR). Assuming that the pooled standard deviation of WTP would be 60 INR (based on a pilot among 21 households), the price difference of 12 INR corresponded to a between-groups effect size of d=.2, which is a small effect according to the convention of Cohen (1988). To obtain statistical power at the recommended 0.8 level with alpha set at 0.05 for a two-tailed test, a sample of 393 would be required. However, if the variance is higher, the required sample size increases substantially. We hence aimed at 500 usable observations for the experiment. Adding 10% to account for different kinds of data problems which may arise resulted in 550 planned interviews. The protocol below describes how these 550 households were sampled.

Figure A1: Sampling protocol



A.3 Summary statistics and balance tests

Table A1: Means and tests of treatment-control covariate balance

	Total mean	Control mean	Treatment mean	Difference b	t
Male	0.08	0.09	0.07	0.01	(0.62)
Age	28.55	28.29	28.81	-0.52	(-0.73)
Education	1.50	1.57	1.43	0.14	(1.43)
Household size	6.00	5.85	6.15	-0.30	(-1.53)
Hindu	0.97	0.98	0.96	0.02	(1.24)
Muslim	0.03	0.02	0.04	-0.01	(-1.02)
BPL	0.60	0.57	0.63	-0.06	(-1.27)
Expenditures	6752.59	6740.38	6764.75	-24.37	(-0.07)
Land	0.66	0.63	0.68	-0.05	(-1.15)
Asset index	-0.01	-0.04	0.01	-0.05	(-0.38)
Refills	0.91	0.90	0.92	-0.02	(-0.88)
LPG consumption	0.24	0.23	0.25	-0.01	(-0.99)
Wood quantity	45.75	47.63	43.85	3.78	(1.17)
Dung quantity	52.47	51.78	53.17	-1.39	(-0.38)
Random price	339.94	336.41	343.48	-7.06	(-1.29)
Content	0.45	0.46	0.44	0.01	(0.53)
Voucher validity	21.05	21.34	20.75	0.59	(0.37)
Subsidy	0.15	0.13	0.17	-0.05	(-0.96)
LPG convenience	1.49	1.48	1.49	-0.01	(-0.20)
Distance	0.46	0.48	0.44	0.04	(0.91)
Refill cost	0.90	0.91	0.90	0.01	(0.31)
Fin. restriction	0.77	0.79	0.75	0.05	(1.26)
Food taste	0.57	0.57	0.56	0.02	(0.38)
Safety	0.24	0.24	0.23	0.01	(0.28)
N	539	270	269	539	

* p<0.1, ** p<0.05, *** p<0.01

Table A2: Means and tests of treatment-control covariate balance for voucher owners

	Total mean	Control mean	Treatment mean	Difference b	t
Male	0.10	0.12	0.07	0.05	(1.49)
Age	28.31	27.97	28.65	-0.67	(-0.73)
Education	1.52	1.55	1.50	0.05	(0.37)
Household size	5.89	5.75	6.03	-0.29	(-1.22)
Hindu	0.97	0.99	0.94	0.05***	(2.60)
Muslim	0.03	0.01	0.05	-0.05**	(-2.40)
BPL	0.57	0.58	0.57	0.01	(0.14)
Expenditures	6511.90	6405.41	6619.86	-214.46	(-0.44)
Land	0.66	0.67	0.65	0.01	(0.24)
Asset index	-0.09	-0.14	-0.04	-0.10	(-0.65)
Refills	0.91	0.89	0.93	-0.04	(-1.14)
LPG consumption	0.25	0.24	0.26	-0.02	(-1.09)
Wood quantity	46.15	47.54	44.72	2.82	(0.68)
Dung quantity	51.99	49.48	54.56	-5.07	(-1.08)
Random price	305.43	301.51	309.40	-7.89	(-1.51)
Content	0.43	0.42	0.44	-0.02	(-0.61)
Voucher validity	20.61	20.42	20.82	-0.40	(-0.20)
Subsidy	0.17	0.14	0.21	-0.08	(-1.14)
LPG convenience	1.50	1.53	1.47	0.06	(0.66)
Distance	0.47	0.44	0.50	-0.06	(-1.08)
Refill cost	0.88	0.87	0.90	-0.03	(-0.84)
Fin. restriction	0.74	0.75	0.72	0.03	(0.56)
Food taste	0.53	0.56	0.51	0.06	(0.97)
Safety	0.25	0.26	0.24	0.02	(0.43)
WTP for LPG	389.83	382.88	396.91	-14.03*	(-1.87)
Voucher value	174.64	178.59	170.60	7.99	(1.53)
N	303	153	150	303	

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table A3: Variable definitions and summary statistics

Variable	Definition	Count	Mean	Std. Dev.	Min	Max
Dependent variables						
WTP	Willingness to pay for LPG	539	356.79	71.34	200.0	750.0
Voucher use	Dummy = 1 if individual used voucher before the household-specific expiry date	296	0.35	0.48	0.0	1.0
Key explanatory variable						
Health information	Dummy = 1 if individual is exposed to health information	539	0.50	0.50	0.0	1.0
Other variables						
Voucher	Dummy = 1 if individual received voucher	539	0.56	0.50	0.0	1.0
Voucher validity	Days until voucher expiry	538	21.05	18.22	3.5	172.0
Voucher value	Voucher value (INR)	303	174.64	45.44	5.0	235.0
Male	Dummy = 1 if individual is male	539	0.08	0.27	0.0	1.0
Age	Age of the individual	539	28.55	8.18	18.0	65.0
Education	Education(Categorical, levels 1-7)	539	1.50	1.16	1.0	7.0

Household size	Number of persons sharing one kitchen	538	6.00	2.31	2.0	20.0
Hindu	Dummy =1 if individual is Hindu	539	0.97	0.17	0.0	1.0
Muslim	Dummy =1 if individual is Muslim	539	0.03	0.17	0.0	1.0
BPL	Dummy = 1 if household holds a BPL card	508	0.60	0.49	0.0	1.0
Expenditures	Household consumption expenditures					
	(INR/month)	521	6752.59	4184.69	400.0	50000.0
Land	Dummy = 1 if household owns land	539	0.66	0.48	0.0	1.0
Asset index	Weighted index of asset ownership	539	-0.01	1.42	-1.4	6.6
Refills	Dummy = 1 if household buys LPG refills	539	0.91	0.29	0.0	1.0
LPG consumption	Estimated LPG consumption HH (cylinder/month)	489	0.24	0.15	0.0	1.7
Wood quantity	Wood quantity used (kg/week)	536	45.75	37.29	0.0	350.0
Dung quantity	Dung quantity used (kg/week)	537	52.47	42.11	0.0	350.0
Content	Estimated content currently used cylinder (%)	468	0.45	0.25	0.0	1.0
Subsidy	Dummy = 1 if household buys					
	subsidized cylinders	232	0.15	0.35	0.0	1.0
LPG convenience	Convenience LPG vs. trad. cooking					
	(1-Better, 2-Similar, 3-Worse)	539	1.49	0.74	1.0	4.0
Distance	Dummy = 1 if distance explains low LPG usage)	539	0.46	0.50	0.0	1.0

Refill cost	Dummy = 1 if refill costs explain low LPG)	539	0.90	0.30	0.0	1.0
Fin. restriction	Refill costs as main hindrance					
	to regular LPG consumption (respondents share)	539	0.77	0.42	0.0	1.0
Food taste	Dummy = 1 if taste of food explains low LPG)	539	0.57	0.50	0.0	1.0
Safety	Dummy = 1 if safety explains low LPG)	539	0.24	0.42	0.0	1.0
Severe effects	Dummy = 1 if aware of severe effects from IAP	503	0.31	0.46	0.0	1.0
Slight effects	Dummy = 1 if aware of slight effects from IAP	503	0.53	0.50	0.0	1.0
No effects	Dummy = 1 if not aware of any effects from IAP	503	0.16	0.37	0.0	1.0
IAP diseases	Share of six IAP-related diseases					
	correctly identified (in %)	539	0.34	0.28	0.0	1.0
All diseases	Share of ten diseases correctly					
	identified as either IAP-related or not	539	0.51	0.15	0.1	0.9
Observations	539					

Sample restricted to respondents taking part in the WTP Experiment.

IAP = Indoor Air Pollution

A.4 Information material used for frames

While this appendix contains English versions of the visualizing posters and texts, the material used in the field was in Hindi language.

A.4.1 Health frame (text for enumerator and poster)

Before we start let me inform you that LPG is very different from firewood and dung cake regarding the health effects of these fuels. You have certainly observed that when cooking with the chulha – especially indoors and with bad ventilation – there is a lot of pollution in the air (*show picture of cooking woman*). According to studies from different universities and research institutions, this pollution causes many more health problems than may be directly observable for the person who cooks and her family. As opposed to what one may think, the effects are not limited to temporary coughing, tearing eyes and throat ache, but also include several severe diseases:

1. Generally, many people in India die much earlier than normal from disease which is caused by air pollution from cooking with solid fuels.

2. A high number of people die for instance prematurely due to a stroke. It occurs when blood flow to an area of the brain is cut off. Every 4th case of death from a stroke is due to staying in the polluted air over a long time.

3. Similarly, indoor air pollution increases the risk for having lung cancer or a heart disease significantly. It is like smoking a very large amount of cigarettes every day, you can see on the picture what can happen to the lung (*show pictures lung diseases and heart diseases*).

4. It also increases the chances to get a cataract/motyaabind (*show picture*

eye diseases). If untreated, cataract/motyaabind can lead to blindness.

5. And it can hinder the development of the children. Women and small children are the most affected from the pollution. When small children die from acute lower respiratory infections like pneumonia, this is due to the indoor air pollution in more than half of the cases (*show picture development of child*). Of course, ventilation helps to reduce these risks. Having an open window and a chimney-hood or cooking outside is therefore helpful. But according to available academic studies, the remaining risks are often considerable and should not be underestimated. When cooking on a chulha, the danger to be hit by the above severe diseases is usually still much stronger than otherwise.

Figure A2: Visualizing poster health frame

A.4.2 Alternative frame (text for enumerator and poster)

Before we start, let me give you some information about how liquefied petroleum gas or LPG, your cooking gas, is produced. LPG is a fossil fuel. Sometimes it is recovered naturally, directly from the ground. Another way of producing LPG is by refining it from crude oil. Crude oil is a thick and black liquid. It is a mixture of different chemicals which can be used as fuel because they burn well. Most crude oil is found by drilling down through rocks on land or off-shore on the bottom of the ocean.

- Look, we have a picture of an oil field off the coast of Mumbai. The oil gets pumped up from a deep hole in the ocean floor (*show picture of oil field off the coast of Mumbai*).

- Crude oil cannot be used as a fuel as it is. Therefore, the crude oil must be transported to a so-called oil refinery as a first step. This can best be done through a crude oil pipeline, which pumps the crude oil from the oil field to a refinery (*show picture of crude oil pipe*). This pipeline transports crude oil from the Barmer district, Rajasthan to Salaya, Gujarat.

- At the oil refinery, the crude oil is heated and then distilled to separate it into different petroleum products (*show picture of oil refinery*). These include gasoline for cars, ship fuel and the petroleum gas used for cooking.

- But gas takes up a lot of space. To make storage easier, the gas is liquefied by compressing with high pressure. This is why your cooking gas is called liquefied petroleum gas or LPG.

- Then the liquefied gas is transported to a bottling plant. There it gets filled into the cylinders that you know (*show picture of bottling plan*). They are small enough for a relatively easy transport. Since the gas is still liquid, it does not take up too much room.

- As a last step, LPG distributors deliver the LPG cylinders to customers in local markets (*show picture of delivery*).

- In some major cities, households do not have to buy the LPG bottled up in cylinders, but instead receive gas through a pipeline in their kitchen (*show picture of woman with stove and gas pipeline*).

- If you release the liquid from the cylinder by turning on your appliance, it turns back into gas.

Figure A3: Visualizing poster alternative frame

A.5 Offer Prices

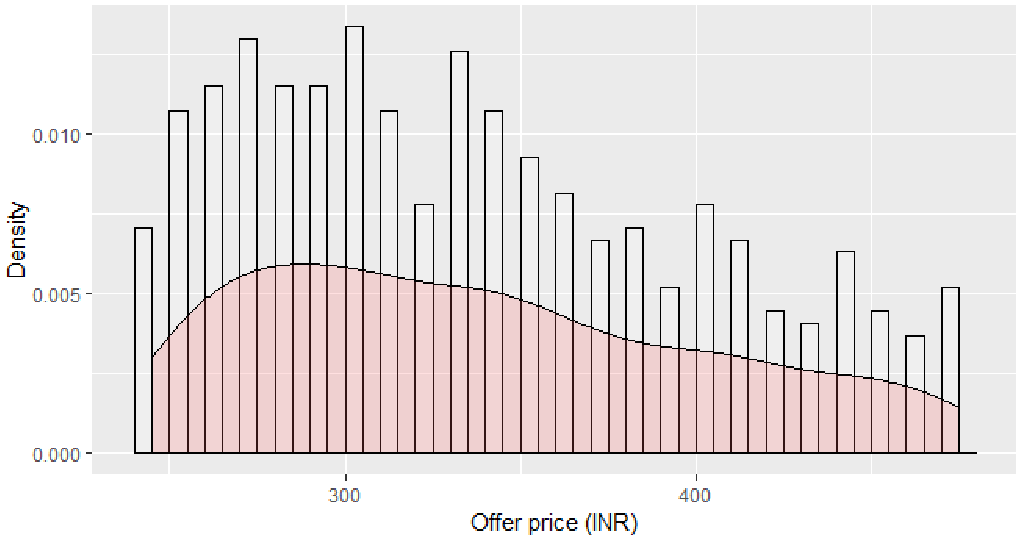
A.5.1 Offer Prices in the WTP eliciting mechanism

Enumerators determine the offer prices p_d used in the WTP eliciting mechanism by drawing a random piece from a set of price-cards covering the range from 245 to 475 INR in steps of 5 INR.

The choice of the price range is based on the following reflection: Even if a household's currently used cylinder was full at the time of the survey and even if its demand for LPG was completely inelastic (i.e., it does not speed-up consumption due to price-reductions), it would be left with a maximum of 50% of the cylinder content (market value = 240 INR) at the expiry date of the voucher, i.e., when the cylinder is to be replaced by a full one. All households should thus accept to replace their currently used cylinder by a full one if they are given a compensation $C = 480 - 240 = 240$ INR, and a higher discount should not be necessary in our context.

Figure A4 shows the empirical distribution of the prices. While prices were drawn from the full range of possible values, their distribution is right skewed. Offer prices below the mean (339) are more frequent than prices that are higher than this average. This is surprising as an approximately uniform distribution of offer prices should have been expected. A chi-square test comparing the observed frequencies to the expected frequencies under a discrete uniform distribution clearly rejects the null-hypothesis that these distributions are equal (p=0.000).

Figure A4: Distribution of offer prices



Histogram with heights of the bars representing observed frequencies of offer-prices and density curve as approximation of the proportion of values in certain price-ranges.

This raises some doubts regarding the random selection. It cannot be excluded for instance that, in some cases, enumerators made the selection only among higher discount values in order to provide extra benefits to the household. However, since WTP is measured before offer prices are drawn, this should not affect our main results.

A.5.2 Offer Prices and voucher use probability

This section examines the effect of the randomly determined offer price in more detail. Table A4 shows the results of a linear probability model estimation that includes the voucher value, i.e., the offered price discount D $(= p_m - p_d)$ as a continuous variable.

Table A4: Joint effect of health information on voucher use

	(1)	(2)	(3)	(4)
Health info	0.058*	0.075**	0.094*	0.115*
	(0.094)	(0.023)	(0.061)	(0.056)
Discount (per 20 INR)		0.038***	0.039***	0.037***
		(0.000)	(0.000)	(0.000)
Discount X Health info			-0.003	-0.003
			(0.764)	(0.787)
Male				0.161*
				(0.064)
Content				-0.081
				(0.369)
Voucher validity				-0.001
				(0.587)
Asset index				0.014
				(0.266)
Land				0.027
				(0.477)
LPG distance				0.003*
				(0.072)
Fin. restriction				0.036
				(0.402)
Education				0.008
				(0.683)
Age				-0.002
				(0.305)
Household size				-0.015**
				(0.024)
Months since LPG adoption				0.003
				(0.313)
Constant	0.169***	-0.104***	-0.114***	-0.053
	(0.000)	(0.000)	(0.000)	(0.622)
adj. R^2	0.003	0.094	0.092	0.104
N	532	531	531	449

Linear probability models, p-values based on heteroskedasticity consistent standard errors in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

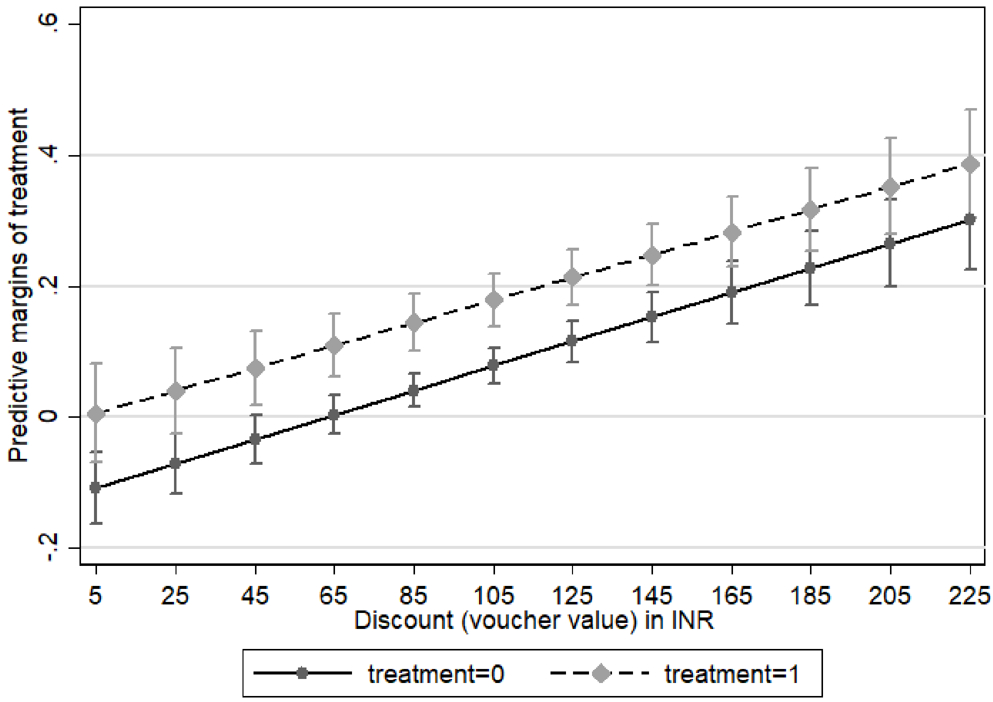
Column 1 reports the point estimate for the uncontrolled comparison between treatment and control group as a baseline (see also Table 4 in Section 5.2.2). Column 2 shows that the treatment effect is hardly affected by the additional inclusion of the offer price.

As compared to Column 1, the estimate in Column 2 slightly increases from 6 to 7 percentage points and becomes more precise, just as in Table 4 when we include offer-price fixed effects. It further increases to 11 percentage points when we add more controls.

The discount itself has a very robust effect of 4 percentage points per 20 INR price reduction (i.e., 10 percentage points per 50 INR). In Columns (3) and (4) we test whether the price reduction interacts with the treatment effect. This does not seem to be the case.

Using the regression in Column 4, Figure A5 illustrates how the predicted probability of voucher use increases with rising discounts (depicted in steps of 20 INR). Corresponding to the insignificant interaction term in Table A4, the lines for the treatment and the control group are about equidistant across the range of discount values. Differences are significant for intermediate voucher values between 45 and 145 INR.

Figure A5: Predicted Probability of voucher use



Linear probability model as estimated in column 4 of Table A4 and 90% CI's